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(54) **INK SUPPLY DEVICE AND IMAGE FORMING APPARATUS**

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B41F 31/00 (2006.01)

(52) **U.S. Cl.**
USPC **347/103**; 101/350.5

(58) **Field of Classification Search**
USPC 347/85, 93, 103; 399/237, 248, 249; 101/350.5
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,497,250	A *	2/1985	Dressler	101/350.5
4,690,055	A *	9/1987	Fadner et al.	101/451
4,757,782	A *	7/1988	Pullinen	118/411
4,864,925	A *	9/1989	Van Kanegan et al.	101/141
4,929,355	A *	5/1990	Ragnegård et al.	210/784
4,981,726	A *	1/1991	Rantanen et al.	427/356
5,079,044	A *	1/1992	Schumacher et al.	427/207.1
5,120,630	A *	6/1992	Wadlo et al.	430/103
5,280,750	A *	1/1994	Yoshida et al.	101/363
5,357,864	A *	10/1994	Ohta et al.	101/483
5,463,453	A *	10/1995	Kurotori et al.	399/249
5,561,264	A *	10/1996	Iino et al.	399/240
5,633,045	A *	5/1997	Smith et al.	427/428.17
5,689,779	A *	11/1997	Miyamoto et al.	399/237
5,724,629	A *	3/1998	Iino et al.	399/57
5,793,400	A *	8/1998	Mukoyama et al.	347/140
6,241,344	B1 *	6/2001	Machida	347/66
6,853,827	B2 *	2/2005	Song et al.	399/237
7,506,975	B2 *	3/2009	Cellura et al.	347/103
7,520,934	B2 *	4/2009	Nojo et al.	118/212
8,282,201	B2 *	10/2012	Kessler	347/93
2002/0148580	A1 *	10/2002	Sugihara et al.	162/135
2004/0135860	A1 *	7/2004	Williams	347/96
2004/0146317	A1 *	7/2004	Park	399/237
2006/0093404	A1 *	5/2006	Chou et al.	399/237
2006/0115762	A1 *	6/2006	Katano et al.	430/124
2007/0147862	A1 *	6/2007	Nakamura et al.	399/45
2009/0003903	A1 *	1/2009	Katano et al.	399/340
2010/0060688	A1 *	3/2010	Hirato	347/14

* cited by examiner

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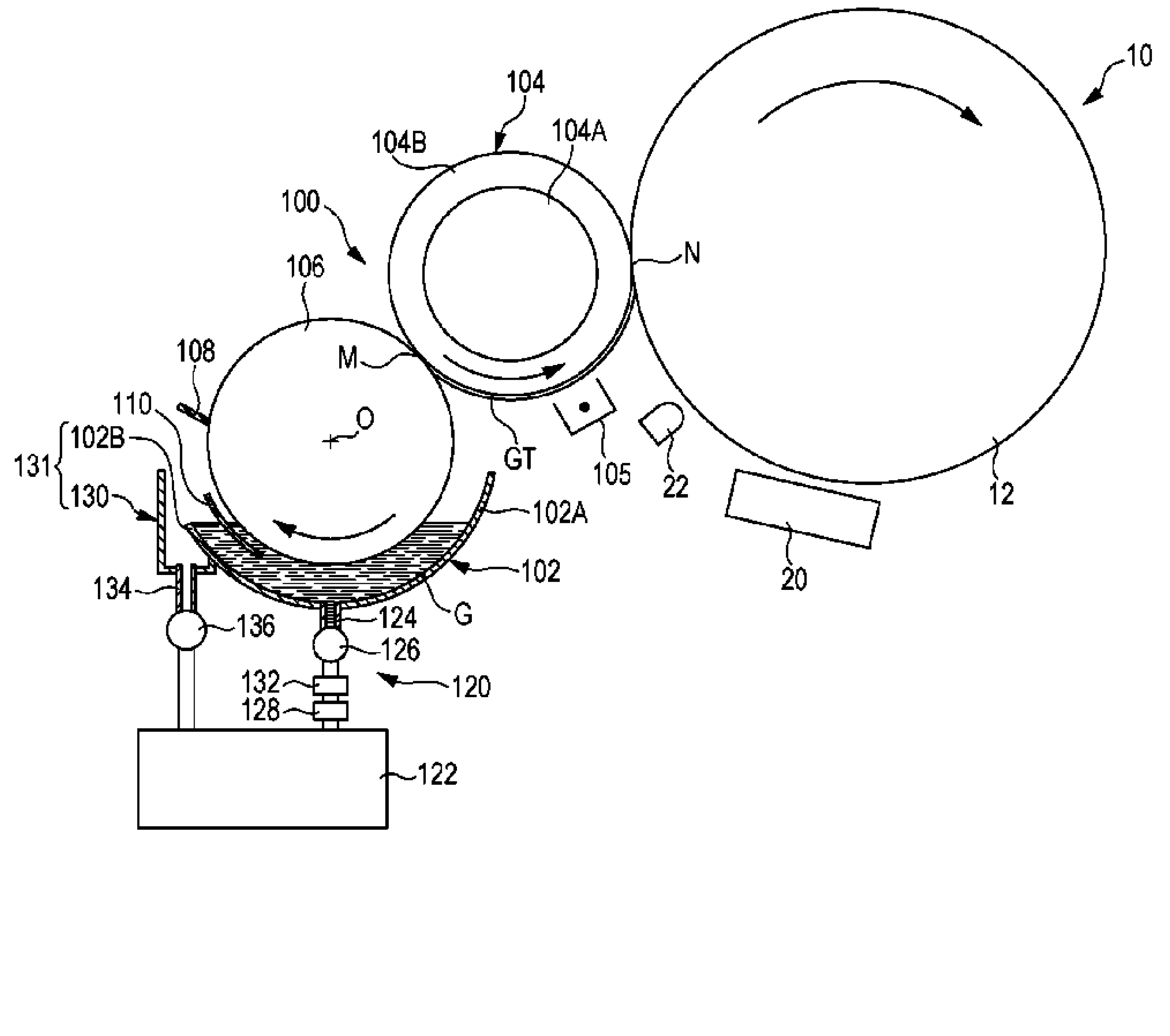
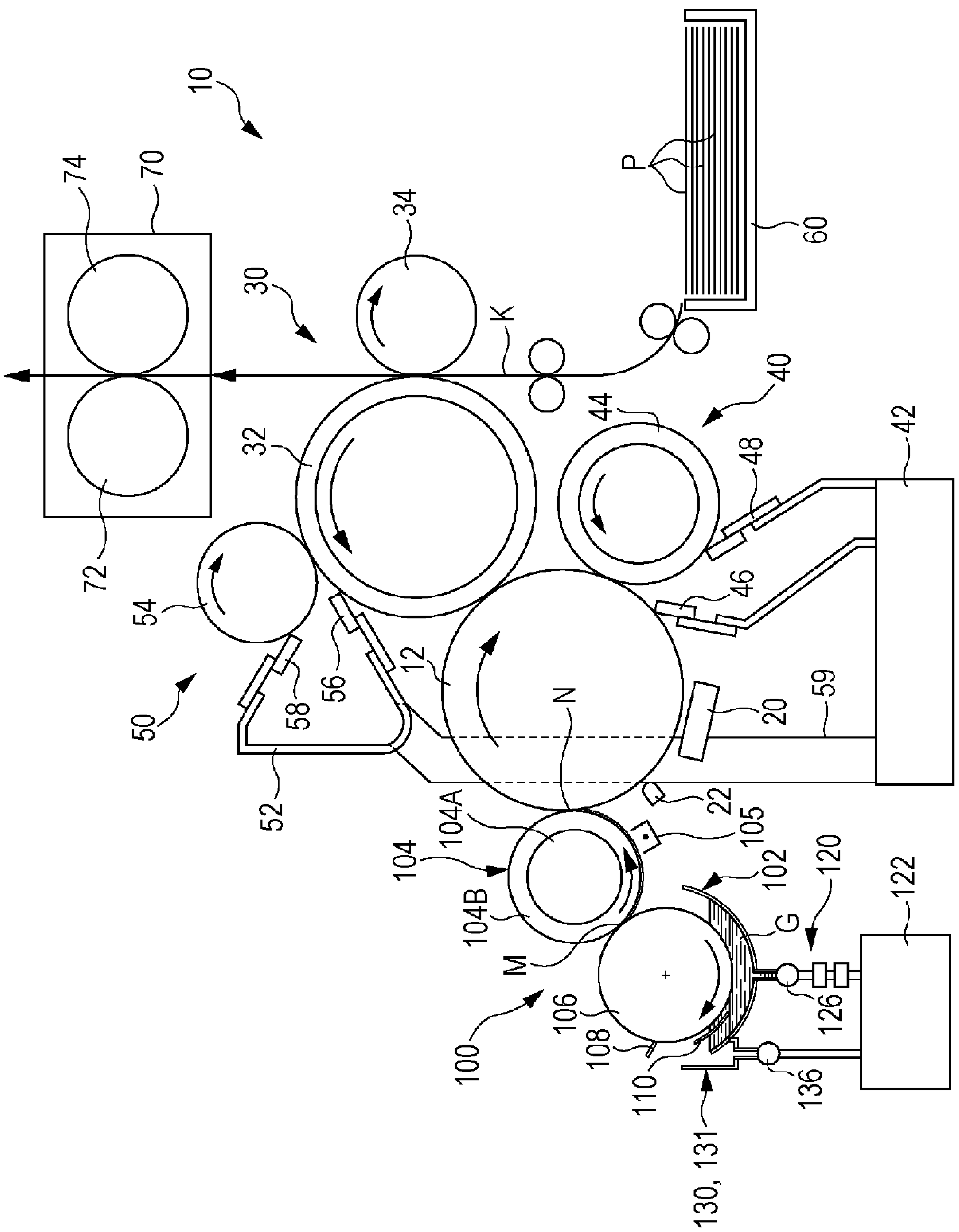
(57) **ABSTRACT**

An ink supply device includes a reservoir; an ink carrying rotary member; a supply rotary member that rotates and supplies ink to the ink carrying rotary member while a part thereof is immersed in the ink in the reservoir; a regulation member that faces an outer peripheral surface of the supply rotary member, the regulation member regulating an amount of ink on the outer peripheral surface of the supply rotary member at a position outside of the reservoir; and a blocking member that extends from below to above a liquid surface of the ink in the reservoir at a position between a landing position and the supply rotary member, the landing position being a position at which ink that has been scraped off by the regulation member lands on the liquid surface, the blocking member blocking movement of the ink from the landing position to the supply rotary member.

4 Claims, 7 Drawing Sheets

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70
74
34
30
76
K
P
60
40
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32
72
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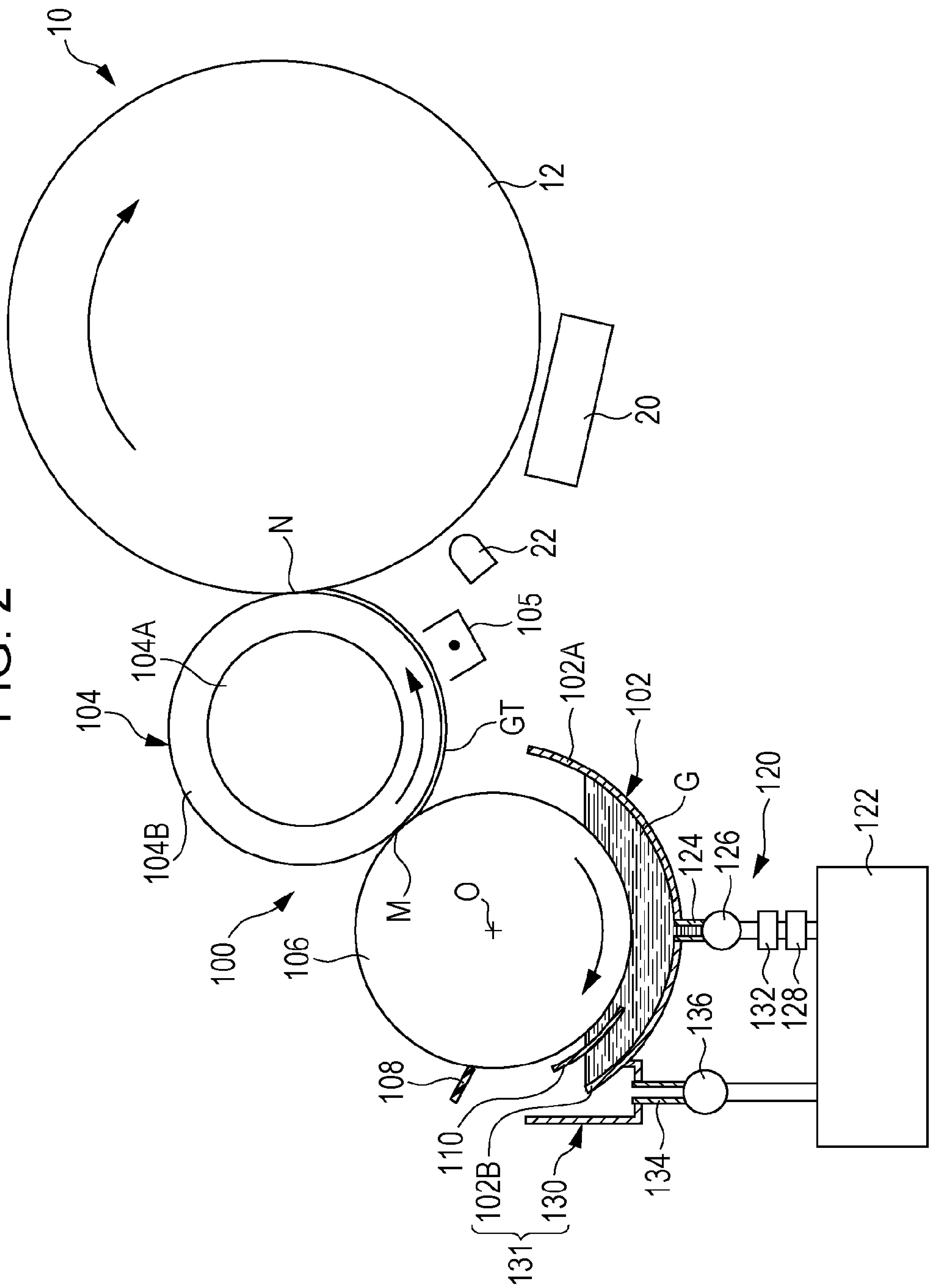
12
56
50
58
N
20
59
52
22
104A
105
104
102
120
122
104B
G
M
106
126
100
108
110
136
130, 131

FIG. 1

FIG. 2



10
12
20
22
N
105
104
104A
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GT
102A
102
G
120
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124
126
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O
132
128
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108
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102B
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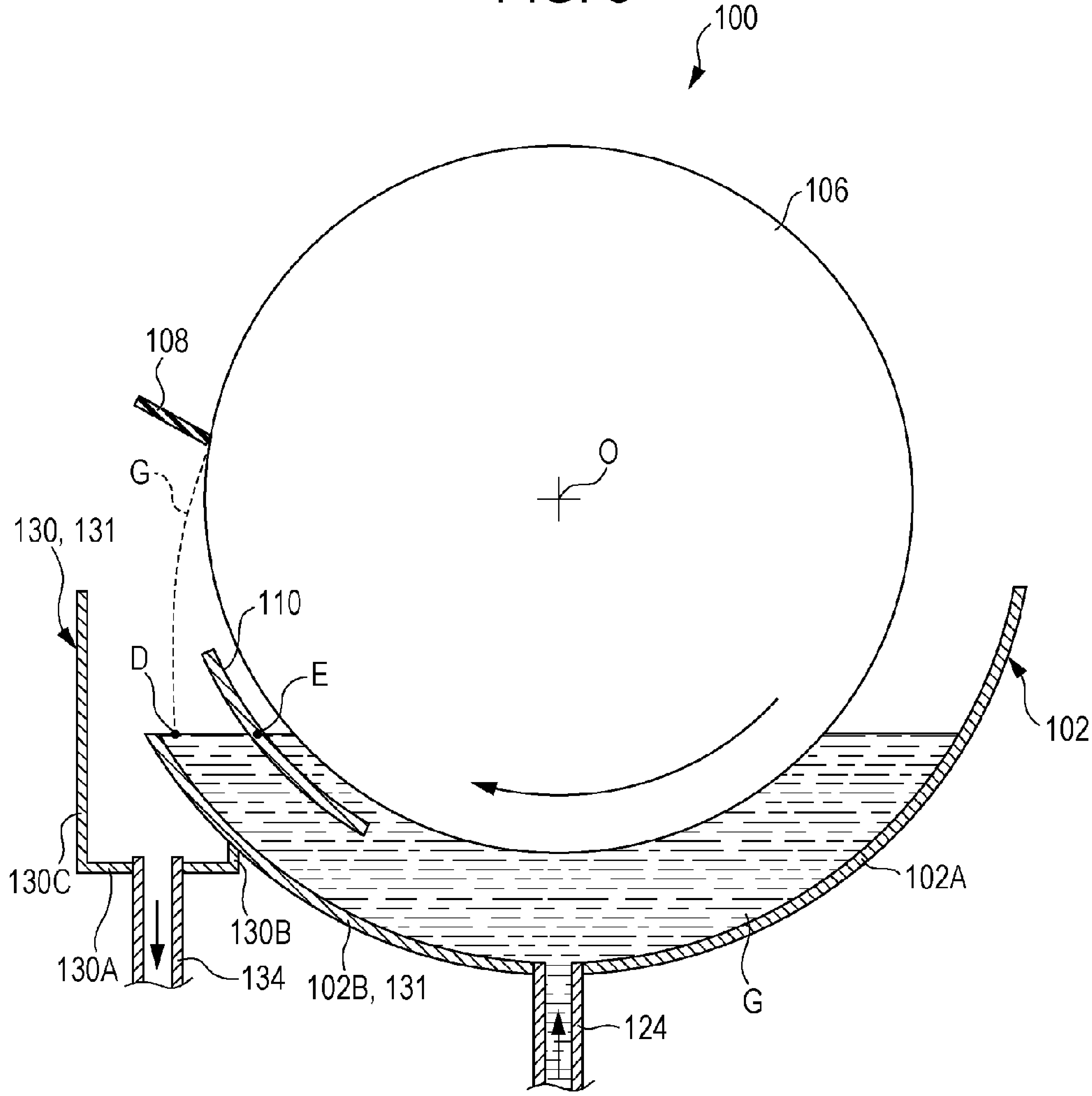
134
131

FIG. 3


100
106
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D
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102A
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130A
134
102B, 131
G
124

FIG. 4

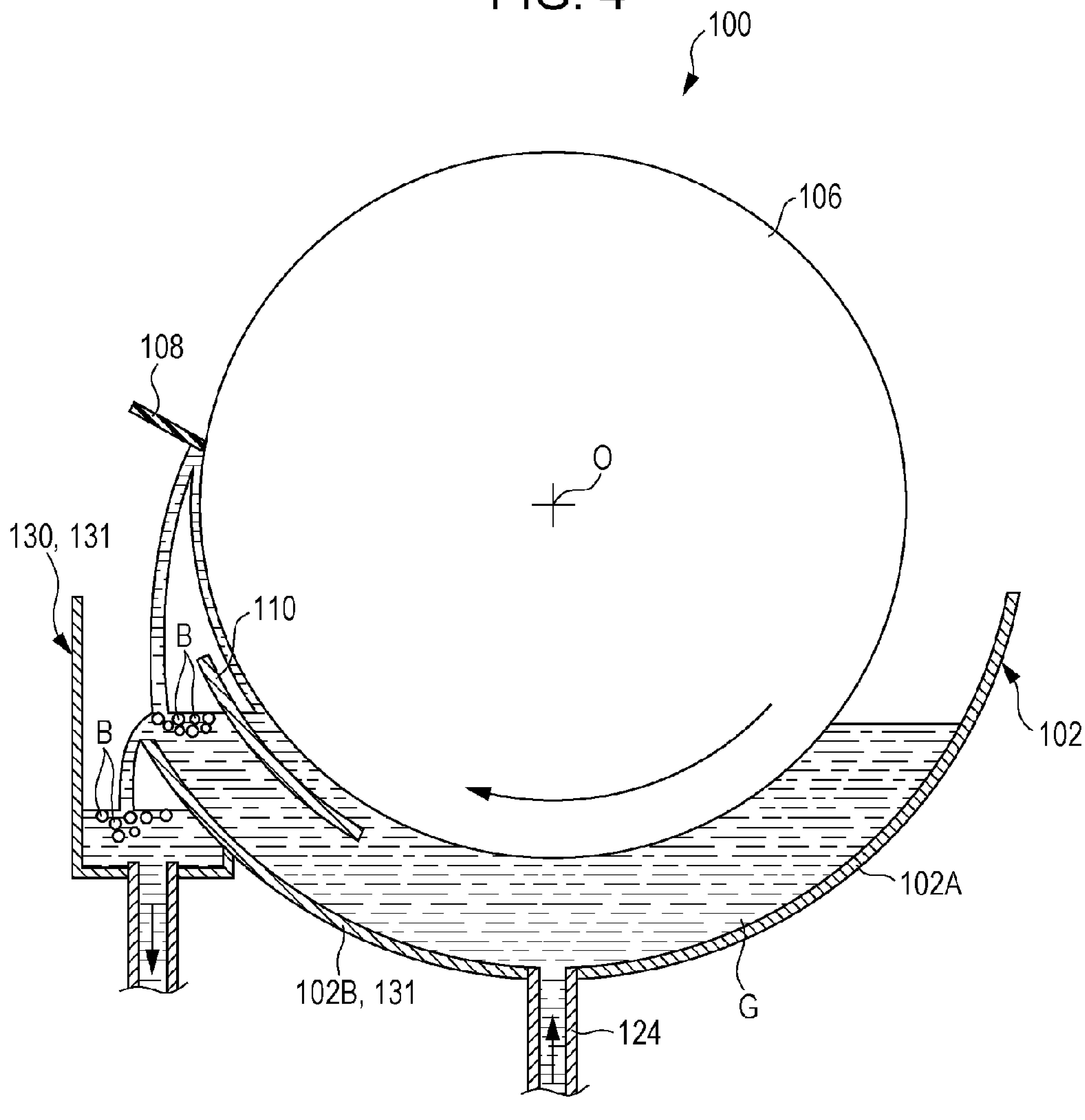


FIG. 5

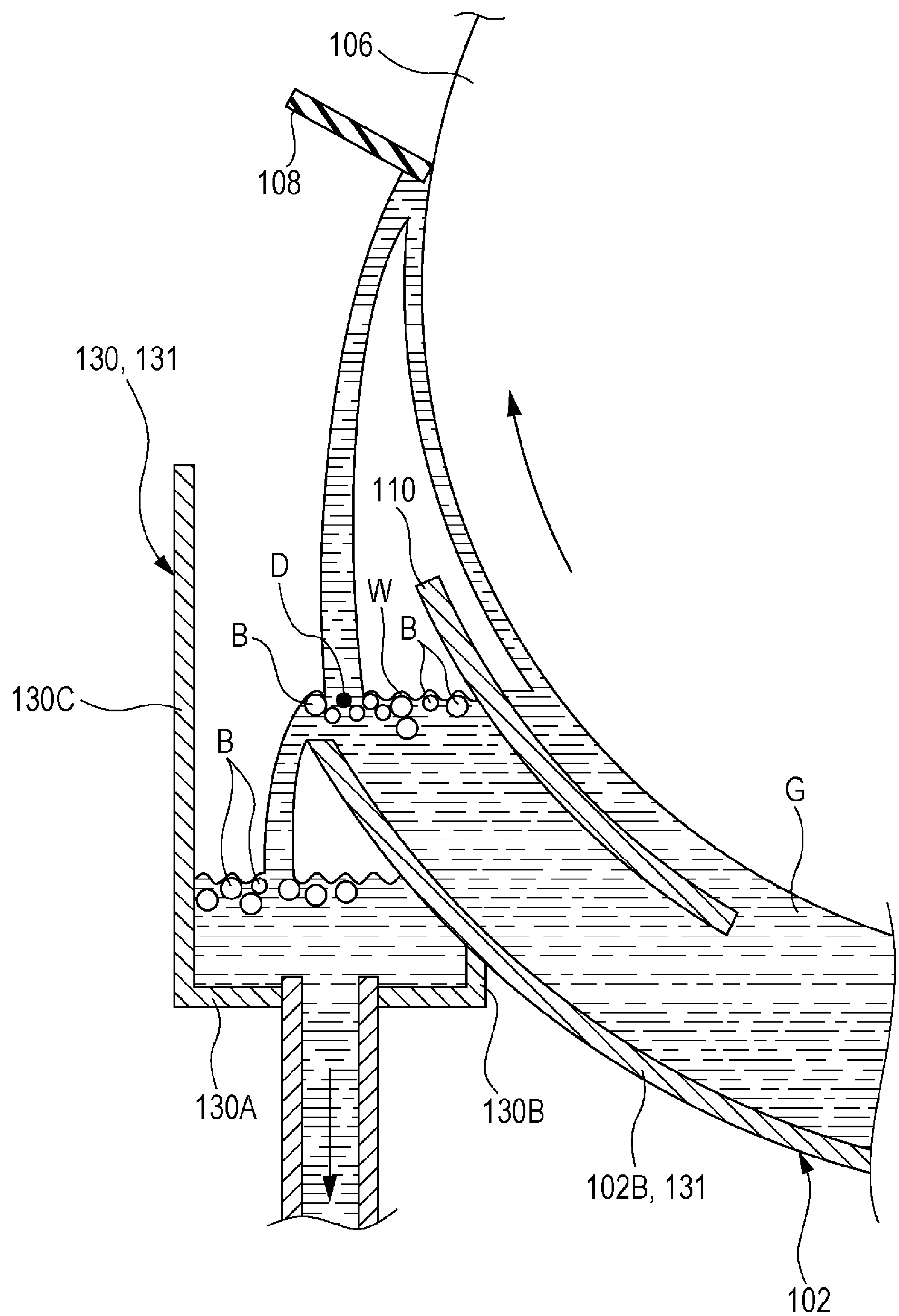
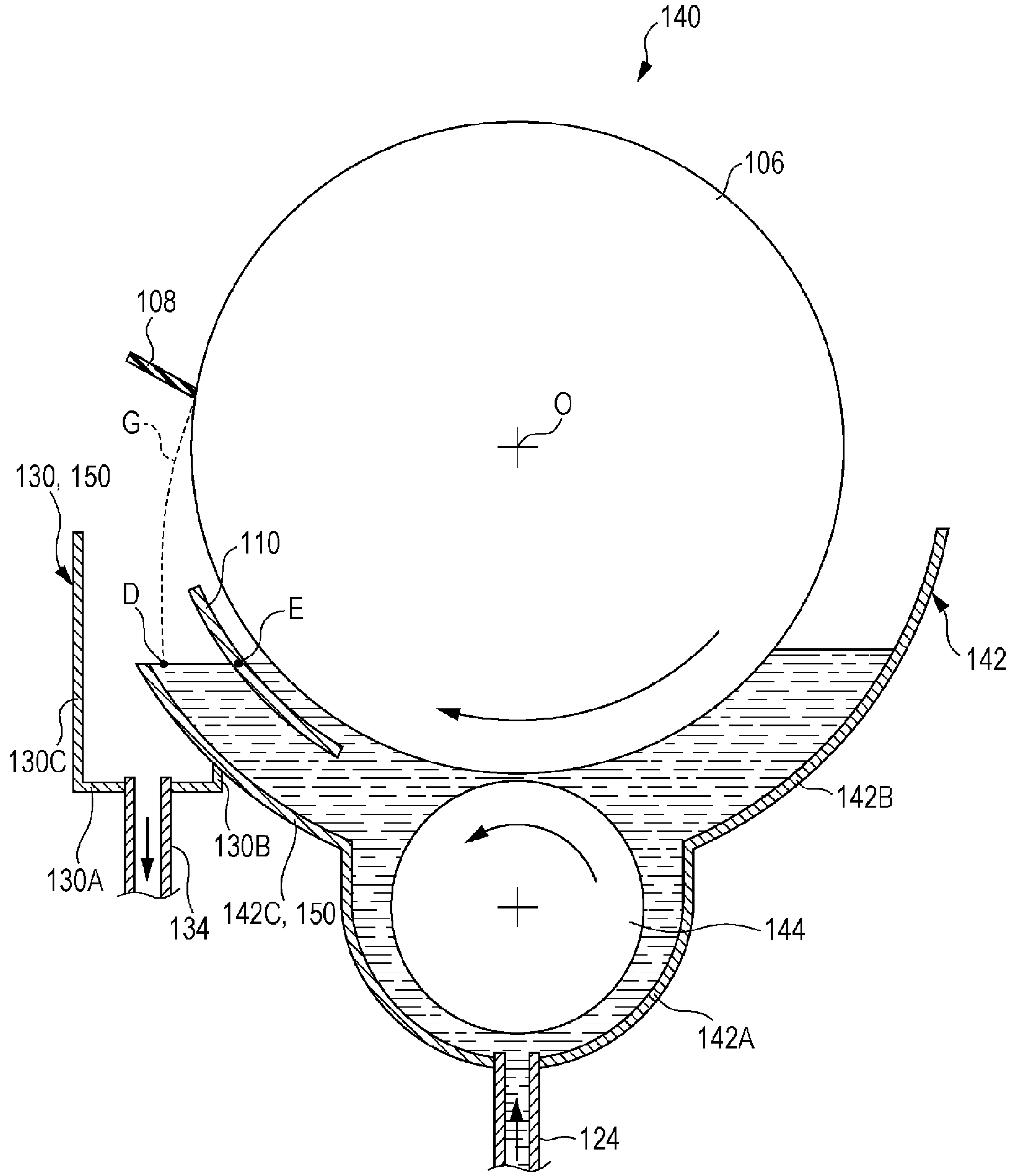


FIG. 6


140
106
108
O
G
130, 150
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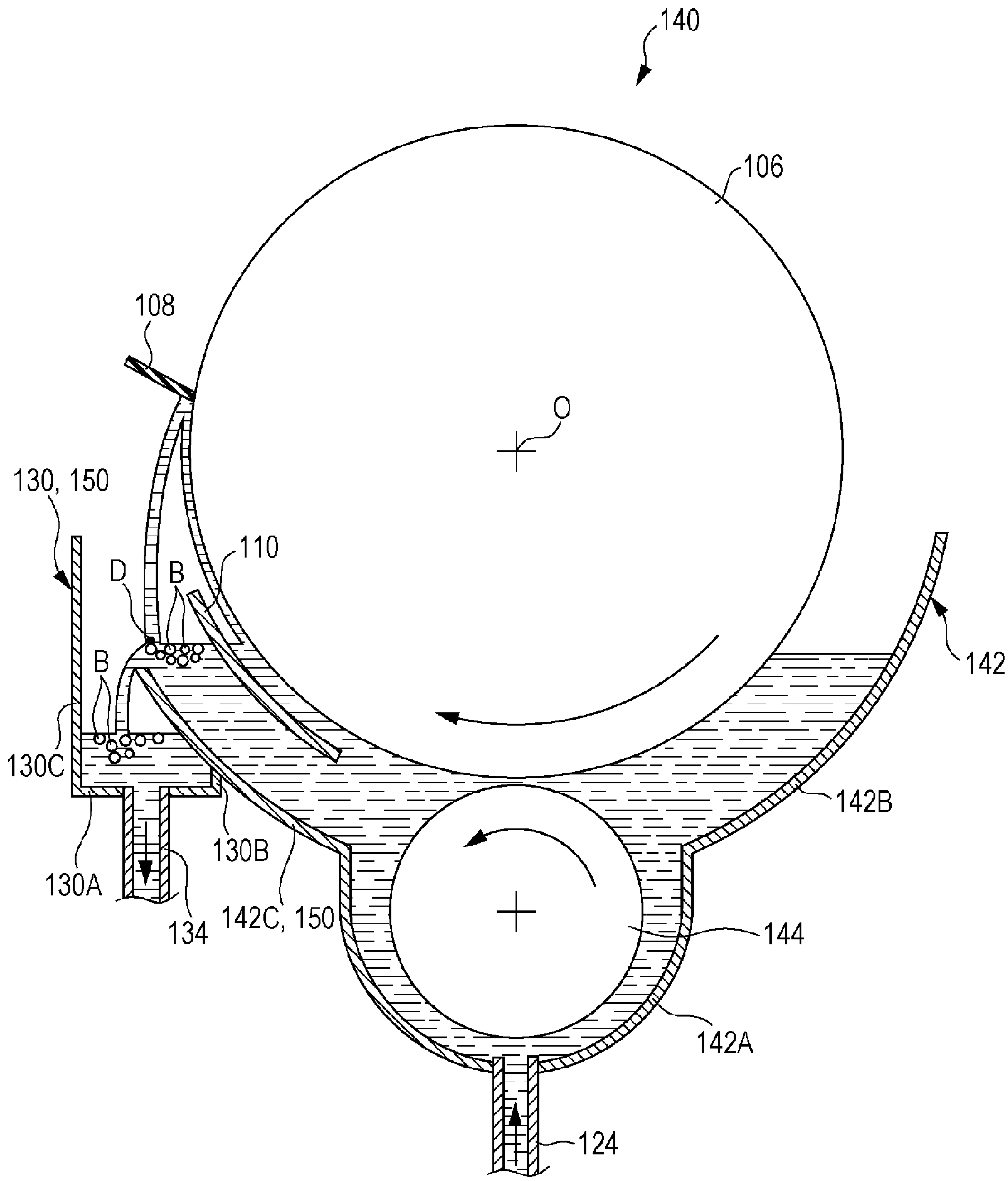
142A
124

FIG. 7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142A
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INK SUPPLY DEVICE AND IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority under 35 USC 119 from Japanese Patent Application No. 2012-028928 filed Feb. 13, 2012.

BACKGROUND

Technical Field

The present invention relates to an ink supply device and an image forming apparatus.

SUMMARY

According to an aspect of the invention, an ink supply device includes a reservoir that stores ink; an ink carrying rotary member that carries ink on an outer peripheral surface thereof; a supply rotary member that is rotatable about a rotation axis that is parallel to a rotation axis of the ink carrying rotary member, the supply rotary member rotating and supplying the ink to the outer peripheral surface of the ink carrying rotary member while a part of the supply rotary member is immersed in the ink in the reservoir; a regulation member that faces an outer peripheral surface of the supply rotary member, the regulation member regulating an amount of ink on the outer peripheral surface of the supply rotary member at a position outside of the reservoir; and a blocking member that extends from below to above a liquid surface of the ink in the reservoir at a position between a landing position and the supply rotary member, the landing position being a position at which ink that has been scraped off by the regulation member lands on the liquid surface, the blocking member blocking movement of the ink in the reservoir from the landing position to the supply rotary member.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present invention will be described in detail based on the following figures, wherein:

FIG. **1** is a schematic view illustrating an image forming apparatus according to a first exemplary embodiment of the present invention;

FIG. **2** is a schematic view illustrating a developing device according to the first exemplary embodiment of the present invention;

FIG. **3** a schematic view illustrating a region surrounding a supply roller of the developing device according to the first exemplary embodiment of the present invention;

FIG. **4** is a schematic view illustrating a region surrounding the supply roller of the developing device according to the first exemplary embodiment of the present invention when bubbles are generated in a liquid developer near the supply roller;

FIG. **5** is a schematic view illustrating a region surrounding the supply roller of the developing device according to the first exemplary embodiment of the present invention when bubbles and waves are generated in the liquid developer near the supply roller;

FIG. **6** is a schematic view illustrating a region surrounding a supply roller of a developing device according to the second exemplary embodiment of the present invention; and

FIG. **7** is a schematic view illustrating a region surrounding the supply roller of the developing device according to the second exemplary embodiment of the present invention when bubbles are generated in the liquid developer near the supply roller.

DETAILED DESCRIPTION

First Exemplary Embodiment

Examples of a developing device, which is an example of an ink supply device, and an image forming apparatus according to a first exemplary embodiment of the present invention will be described.

Overall Structure

FIG. **1** illustrates an image forming apparatus **10**, which is an example of the first exemplary embodiment. The image forming apparatus **10** includes a photoconductor **12**, which is an example of an image carrier that is cylindrical and rotatable and that carries a latent image on the outer peripheral surface thereof. A charger **20**, an exposure device **22**, a developing device **100**, a transfer device **30**, and a photoconductor cleaner **40** are arranged around the photoconductor **12**. The transfer device **30** is an example of a transfer unit. The developing device **100** is an example of an ink supply device.

The charger **20** is disposed below the photoconductor **12** so as to face the outer peripheral surface of the photoconductor **12** with a distance therebetween. The charger **20** is, for example, a scorotron charger. The charger **20** charges the surface (outer peripheral surface) of the photoconductor **12** by performing corona discharge.

The exposure device **22** is disposed downstream of the charger **20** in the rotation direction of the photoconductor **12**. The exposure device **22** is, for example, an LED exposure device. The exposure device **22** exposes the outer peripheral surface of the photoconductor **12**, which has been charged by the charger **20**, to light on the basis of image information, thereby forming a latent image on the outer peripheral surface of the photoconductor **12**. The exposure device **22** may be a device other than an LED exposure device. For example, the exposure device **22** may be a device that performs exposure by emitting a laser beam.

The developing device **100** includes a development roller **104**, which is an example of an ink carrying rotary member, and a supply roller **106**, which is an example of a supply rotary member. The supply roller **106** supplies a liquid developer G, which is an example of ink, to an outer peripheral surface of the development roller **104**. The developing device **100** is disposed downstream of the exposure device **22** in the rotation direction of the photoconductor **12**. The developing device **100** develops the latent image (forms a visible image) on the photoconductor **12** using the liquid developer G composed of a carrier liquid and a toner (toner particles) dispersed in the carrier liquid, thereby forming a toner image (developer image) on the outer peripheral surface of the photoconductor **12**. The details of the developing device **100** and the liquid developer G will be described below.

The transfer device **30** is disposed downstream of the developing device **100** in the rotation direction of the photoconductor **12**. The transfer device **30**, which is a device using an intermediate transfer method, includes an intermediate transfer member **32**, an intermediate transfer member cleaner **50**, and a transfer roller **34**. The intermediate transfer member **32** is a cylindrical member to which a toner image formed on the outer peripheral surface of the photoconductor **12** is transferred. The transfer roller **34** transfers the toner image, which has been transferred to the outer peripheral surface of the intermediate transfer member **32**, to a recording sheet P, which is an example of a recording medium. That is, the transfer device **30** transfers the toner image via the intermediate transfer member **32** to the recording sheet P using the transfer roller **34**.

The transfer device **30** may have a structure that is different from the structure described above. For example, the intermediate transfer member may have a belt-like shape. The transfer device **30** may be a device using a direct-transfer method, which does not include an intermediate transfer member and an intermediate transfer member cleaner and directly transfers a toner image from the photoconductor **12** to the recording sheet P using the transfer roller **34**.

The photoconductor cleaner **40** includes a first waste toner tank **42**, a cleaning roller **44**, and cleaning blades **46** and **48**. The cleaning roller **44** is in contact with the outer peripheral surface of the photoconductor **12** at a position upstream of the charger **20** in the rotation direction of the photoconductor **12**. The cleaning blades **46** and **48** are made from a polyurethane rubber. The cleaning blades **46** and **48**, which are respectively in contact with the photoconductor **12** and the cleaning roller **44**, remove the liquid developer G that remains on the outer peripheral surface of the photoconductor **12** after transfer of a toner image has been finished. The removed liquid developer G is recovered into the first waste toner tank **42**.

The intermediate transfer member cleaner **50** includes a second waste toner tank **52**, a cleaning roller **54** that is in contact with the outer peripheral surface of the intermediate transfer member **32**, and cleaning blades **56** and **58** made from a polyurethane rubber. The cleaning blades **56** and **58**, which are respectively in contact with the intermediate transfer member **32** and the cleaning roller **54**, remove the liquid developer G. The removed liquid developer G is recovered into the second waste toner tank **52**. The liquid developer G that has been recovered into the second waste toner tank **52** flows through a pipe **59** to the first waste toner tank **42**.

The cleaning roller **44** for the photoconductor **12** and the cleaning roller **54** for the intermediate transfer member each include a metal core shaft made from a stainless steel and a rubber coating formed on the surface of the metal core shaft. The rubber coating may be made from an oil-resistant rubber, such as NBR (acrylonitrile-butadiene rubber) or ECO (epichlorohydrin rubber). The thickness of the rubber coating is, for example, in the range of 5 to 20 mm. The entirety of the cleaning roller for the intermediate transfer member may be made from a metal such as aluminum, iron, or a stainless steel. In this case, the smoothness and the wear resistance of the surface of the cleaning roller may be increased by plating the surface with of the roller.

The image forming apparatus **10** includes a sheet container **60** in which recording sheets P are contained, and the recording sheets P are transported one by one along a transport path K. Moreover, the image forming apparatus **10** includes a fixing unit **70** that fixes a toner image on the recording sheet P, to which the toner image has been transferred. The fixing unit **70** fixes the toner image using, for example, a contact thermal fixing method, which uses a fixing roller **72** and a pressing roller **74**. Alternatively, the fixing method may be a contact thermal fixing method using a fixing roller or a fixing belt or may be a non-contact thermal fixing method using an oven or a flash lamp.

Image Forming Process

Next, the process of forming an image with the image forming apparatus **10** will be described.

Each of the rollers is rotated by a driving device (not shown) or is rotated by another roller in the directions indicated by arrows.

As illustrated in FIG. **1**, the charger **20** charges the surface of the photoconductor **12** and the exposure device **22** forms a latent image on the basis of image information. The developing device **100** develops the latent image on the surface of the photoconductor **12**, thereby forming a toner image on the surface of the photoconductor **12**.

Subsequently, a bias voltage is applied to the core metal shaft (not shown) of the intermediate transfer member **32**, and the toner image formed on the photoconductor **12** is first-transferred to the outer peripheral surface of the intermediate transfer member **32** due to the potential difference between the intermediate transfer member **32** and the photoconductor **12**, which is grounded. The toner image, which has been first-transferred, is second-transferred to the recording sheet P due to the potential difference between the bias voltage applied to the intermediate transfer member **32** and the bias voltage applied to the transfer roller **34**.

Subsequently, the recording sheet P, to which the toner image has been transferred, is transported to the fixing unit **70**, which fixes the toner image onto the recording sheet P. The recording sheet P, to which the toner image has been fixed, is output to an output unit **76** that is disposed at an the end of a transport path K in the image forming apparatus **10**.

The photoconductor cleaner **40** removes the liquid developer G that was not first-transferred to the intermediate transfer member **32** and that remains on the photoconductor **12**. The intermediate transfer member cleaner **50** removes the liquid developer G that was not second-transferred to the intermediate transfer member **32** and that remains on the intermediate transfer member **32**.

Toner included in the remaining liquid developer G is removed by being attracted to the cleaning roller **44** for the photoconductor and the cleaning roller **54** for the intermediate transfer member, because bias voltages are applied to the core metal shafts of the cleaning rollers **44** and **54**. After the toner included in the remaining liquid developer G has been removed, the cleaning roller **44** for the photoconductor and the cleaning roller **54** for the intermediate transfer member remove the carrier liquid.

Structure of Developing Device

Next, the developing device **100** will be described.

As illustrated in FIG. **2**, the developing device **100** includes a reservoir **102**, the development roller **104**, the supply roller (anilox roller) **106**, a regulation blade **108**, and a blocking member **110**. The reservoir **102** stores the liquid developer G. The development roller **104**, which is an example of an ink carrying rotary member, carries the liquid developer G on the outer peripheral surface thereof. The supply roller **106**, which is an example of a supply rotary member, supplies the liquid developer G to the outer peripheral surface of the development roller **104**. The regulation blade **108**, which is an example of a regulation member, regulates the amount of liquid developer on the outer peripheral surface of the supply roller **106**. The blocking member **110** blocks movement of the liquid developer G from a landing position to the supply roller **106**. Here, the landing position (described below in detail) is a position at which the liquid developer G that has been scraped off by the regulation blade **108** lands on the liquid surface of the liquid developer G.

The developing device **100** further includes a developer supply portion **120** and an overflow portion **131**. The developer supply portion **120**, which is an example of an ink supply unit, supplies the liquid developer G into the reservoir **102**. The overflow portion **131**, which is included in the reservoir **102**, includes a second curved wall **102**B that allows the liquid developer G to overflow. The overflow portion **131** includes a receiving portion **130** that receives the liquid developer G that has flowed over the second curved wall **102**B.

The liquid developer G includes a carrier liquid and a toner (toner particles) dispersed in the carrier liquid. An insulating liquid such as a vegetable oil, a liquid paraffin, or a silicone oil is used as a carrier liquid. For example, the liquid developer G includes toner particles having an average particle diameter in the range of 0.5 to 5 μm, and the toner particles are dispersed in the carrier liquid with a concentration in the range of 15 to 35 wt %. The liquid developer G may further include a charge control agent or a dispersing agent. The higher the temperature of the liquid developer G (carrier liquid), the lower the viscosity of the liquid developer G, and vice versa.

The reservoir **102** is a container that extends in a longitudinal direction that is the same as the direction of the rotation axis (hereinafter, referred to as the axial direction) of the supply roller **106** and has a cross section intersecting the longitudinal direction having an arc shape that is open upward. When the reservoir **102** is seen in the longitudinal direction, a first curved wall **102**A and the second curved wall **102**B are located along the same arc and are integrated with each other.

The first curved wall **102**A, which has an arc-shaped cross section, is disposed at a position below the rotation center O of the supply roller **106** (on the lower right side in FIG. **2**) so as to face the outer peripheral surface of the supply roller **106**. The first curved wall **102**A is disposed such that the distance between the first curved wall **102**A and the outer peripheral surface of the supply roller **106** is substantially uniform along the circumferential direction of the supply roller **106**.

The second curved wall **102**B, which has an arc-shaped cross section (extending toward the receiving portion **130**), is disposed at a position below the rotation center O of the supply roller **106** (on the lower left side in FIG. **2**) so as to face the outer peripheral surface of the supply roller **106**. When the reservoir **102** is seen in the longitudinal direction, the upper end of the first curved wall **102**A is higher than the upper end of the second curved wall **102**B. The liquid developer G is stored in the reservoir **102**.

Moreover, for example, a liquid surface detection sensor (not shown) that measures the amount of the liquid developer G remaining in the reservoir **102** is disposed in the reservoir **102**. When the amount of the liquid developer G in the reservoir **102** decreases and becomes insufficient, the developer supply portion **120** supplies new liquid developer G to the reservoir **102**. The amount of the liquid developer G in the reservoir **102** is determined to be insufficient if, for example, the liquid surface of the liquid developer G is below the lower end of the blocking member **110** described below. Alternatively, the liquid developer G may be constantly supplied to the reservoir **102** without using such a sensor for measuring the amount of remaining liquid developer G.

The development roller **104** includes a cylindrical core roller **104**A and a semi-conductive elastic layer **104**B formed on the core roller **104**A. For example, the core roller **104**A is made from a metal, and the semi-conductive elastic layer **104**B has a volume resistivity in the range of 1×10^5 to 1×10^{10} Ω·cm. A bias voltage is applied to the core roller **104**A, which is made from a metal.

The supply roller **106** is in contact with the elastic layer **104**B of the development roller **104** in a layer forming region M, and a developer layer GT of the liquid developer G is formed on the development roller **104** in the layer forming region M. Moreover, the photoconductor **12** is in contact with the elastic layer **104**B of the development roller **104** in a developing nip region N, and the liquid developer G of the developer layer GT is transferred to the photoconductor **12** in the developing nip region N. Liquid developer (not shown) that was not transferred to the photoconductor **12** remains on a side of the development roller **104** downstream of the developing nip region N in the rotation direction of the development roller **104**. At the layer forming region M, the supply roller **106** and the development roller **104** move (rotate) in the same direction. At the developing nip region N, the development roller **104** and the photoconductor **12** move (rotate) in the same direction.

A charger **105** is disposed at the periphery of the development roller **104** at a position between the layer forming region M and the developing nip region N (so as to face the outer peripheral surface of the development roller **104**). The charger **105** charges a part of the surface of the developer layer GT between the layer forming region M and the developing nip region N. In other words, the charger **105** charges the developer layer GT at a position upstream of the photoconductor **12** in the rotation direction of the development roller **104**. The charger **105** charges the developer layer GT with a polarity the same as that of the toner of the liquid developer G that forms the developer layer GT. The charger **105** is, for example, a corotron charger, which charges the developer layer GT by performing corona discharge.

The supply roller **106** is rotatable about an axis that extends in a direction the same as the axial direction of the development roller **104**. A lower portion of the supply roller **106** is immersed in the liquid developer G in the reservoir **102**, and the supply roller **106** is in contact with the development roller **104** at a part thereof that is not immersed in the liquid developer G. The supply roller **106** rotates while a portion (a lower portion) is immersed in the liquid developer G in the reservoir **102**, and thereby the supply roller **106** carries the liquid developer G on the outer peripheral surface thereof and supplies the liquid developer G to the outer peripheral surface of the development roller **104**.

Grooves in a diagonal pattern, for example, are formed in the outer peripheral surface of the supply roller **106**. Besides the diagonal pattern, the pattern of the grooves in the surface of the supply roller **106** may be a pyramidal pattern, a grid pattern, a honeycomb pattern, or the like.

The regulation blade **108** is, for example, a plate-shaped member extending in a longitudinal direction that is the same as the axial direction of the supply roller **106**. The regulation blade **108** is disposed so as to face the outer peripheral surface of the supply roller **106**, and an end portion of the regulation blade **108** in the transversal direction is in contact with the outer peripheral surface of the supply roller **106** (on the upper left side with respect to the rotation center O in FIG. **2**). Thus, the regulation blade **108** regulates the amount of the liquid developer G on the outer peripheral surface of the supply roller **106** at a position outside of the reservoir **102**. As long as the regulation blade **108** is capable of regulating the amount of the liquid developer G that is carried by the supply roller **106**, the regulation blade **108** may be disposed such that the end portion in the transversal direction faces the outer peripheral surface of the supply roller **106** with a gap therebetween.

As illustrated in FIG. **3**, the blocking member **110** is, for example, a member that extends in the longitudinal direction, which is the same as the axial direction of the supply roller **106**, and that has an arc-shaped cross section taken along a plane intersecting the longitudinal direction. Both end portions of the blocking member **110** in the longitudinal direction are located outside of both end portions of the supply roller **106** in the axial direction. In the cross-sectional view taken along a plane intersecting the longitudinal direction, the liquid developer G that has been scraped off by the regulation blade **108** lands onto the liquid surface of the liquid developer

G in the reservoir **102** at a position D (hereinafter referred to as the landing position D). A part of the blocking member **110** is immersed in the liquid developer G such that the blocking member **110** extends from below to above the liquid surface of the liquid developer G at a position E that is between the position D and the supply roller **106**. The blocking member **110** extends along the circumferential direction of the supply roller **106** such that the distance between the blocking member **110** and the outer peripheral surface of the supply roller **106** is substantially uniform.

The landing position D on the liquid surface of the liquid developer G in the reservoir **102** is determined, for example, as follows. An experiment is performed to obtain the positions at which the liquid developer G lands on the liquid surface of the liquid developer G when the liquid developer G falls (as illustrated by a broken line) from the distal end of the regulation blade **108** (an end adjacent to the supply roller **106**) when the supply roller **106** rotates at a predetermined speed. The landing position D is determined as one of the obtained positions that is closest to the outer peripheral surface of the supply roller **106**.

As illustrated in FIG. **2**, the developer supply portion **120** includes a storage tank **122**, a supply path **124**, and a pump **126**. The storage tank **122** stores the liquid developer G therein. The supply path **124** connects the storage tank **122** to the reservoir **102**. The pump **126** is disposed in the supply path **124** and supplies the liquid developer G from the storage tank **122** through the supply path **124** to the reservoir **102**. A degassing unit **128** and a toner concentration sensor **132** are disposed in the supply path **124** between the storage tank **122** and the pump **126**. The degassing unit **128** removes bubbles from the liquid developer G. The toner concentration sensor **132** measures the concentration of toner (particles) in the liquid developer G.

For example, toner (particles) and a carrier liquid are supplied to the storage tank **122** from different supply units. The toner and the carrier liquid are agitated in the storage tank **122** to form the liquid developer G in the storage tank **122**, and the liquid developer G is stored in the storage tank **122**.

The supply path **124** includes, for example, a pipe. One end of the supply path **124** is connected to the storage tank **122** and the other end of the supply path **124** is connected to the deepest portion of the reservoir **102**.

The pump **126**, for example, is operated on the basis of information sent from the aforementioned liquid surface detection sensor (not shown) for measuring the height of the liquid surface of the liquid developer G stored in the reservoir **102**. That is, the pump **126** starts operating when information indicating shortage of the liquid developer G in the reservoir **102** is input from the liquid surface detection sensor, and the pump **126** stops operating when such information is not input from the liquid surface detection sensor.

The degassing unit **128**, for example, has two chambers, and while the liquid developer G flows through one of the chambers, bubbles are removed from the liquid developer G by depressurizing the other chamber. The degassing unit **128** is disposed upstream (on a side nearer to the storage tank **122**) of the toner concentration sensor **132** in the flow direction of the liquid developer G.

The toner concentration sensor **132** includes, for example, a light-emitting element and a light-receiving element (not shown) and measures the concentration of toner on the basis of the amount of light that has been emitted by the light-emitting element and passed through the liquid developer G and that is received by the light-receiving element. That is, the higher the proportion of light that is blocked, the higher the toner concentration. If the toner concentration measured by the toner concentration sensor **132** is higher than a reference concentration, the carrier liquid is supplied to the storage tank **122**. If the toner concentration measured by the toner concentration sensor **132** is lower than the reference concentration, the toner (partially including the carrier liquid) is supplied to the liquid developer G. Thus, the toner concentration in the liquid developer G is adjusted.

As illustrated in FIG. **3**, the second curved wall **102**B is located opposite the supply roller **106** with the landing position D of the liquid developer G falling from the regulation blade **108** therebetween. The receiving portion **130** is disposed outside of the second curved wall **102**B. The receiving portion **130** extends in a longitudinal direction that is the same as the axial direction of the supply roller **106**. The receiving portion **130** includes a bottom wall **130**A, a side wall **130**B, and a side wall **130**C. In a cross-sectional view taken along a plane intersecting the longitudinal direction, the bottom wall **130**A has a plate-like shape, the side wall **130**B stands upright at one end of the bottom wall **130**A (on a side near the second curved wall **102**B), and the side wall **130**C stands at the other end of the bottom wall **130**A (on a side opposite to the side on which the second curved wall **102**B is located).

The position of the bottom wall **130**A in the vertical direction is higher than that of a position at which the supply path **124** is connected to the reservoir **102** and lower than that of the upper end of the second curved wall **102**B. The upper end of the side wall **130**B is attached to the lower surface of the second curved wall **102**B. The side wall **130**C extends vertically upward to a position that is higher than the upper end of the second curved wall **102**B.

As illustrated in FIG. **2**, the developing device **100** further includes a recovery path **134** and a pump **136**. The recovery path **134** connects the storage tank **122** to the receiving portion **130** (bottom wall **130**A). The pump **136** is disposed in the recovery path **134** and recovers the liquid developer G from the receiving portion **130** to the storage tank **122**. Alternatively, instead of using the pump **136**, the developing device **100** may be configured such that the liquid developer G flows to the storage tank **122** on its own weight.

The recovery path **134** includes, for example, a pipe having one end connected to the storage tank **122** and the other end connected to the bottom wall **130**A of the receiving portion **130**. The pump **136** is operated, for example, at set times.

Operation

Next, the operation of the first exemplary embodiment will be described.

As illustrated in FIG. **2**, a controller (not shown) of the image forming apparatus **10** activates the pump **126**, and the liquid developer G is supplied from the storage tank **122** to the reservoir **102**. After the degassing unit **128** has degassed the liquid developer G, the toner concentration sensor **132** measures the toner concentration of the liquid developer G, and the liquid developer G is supplied into the reservoir **102**. As a result, the height of the liquid surface of the liquid developer G in the reservoir **102** reaches the height of the upper end of the second curved wall **102**B.

Subsequently, as illustrated in FIG. **4**, the supply roller **106** starts rotating when an image forming operation starts, and the liquid developer G is carried on the outer peripheral surface of the supply roller **106**. A part of the liquid developer G carried on the outer peripheral surface of the supply roller **106** passes the regulation blade **108** and is supplied to the development roller **104**, and the remaining part of the liquid developer G is scraped off the outer peripheral surface by the regulation blade **108** toward the reservoir **102**.

Subsequently, as illustrated in FIG. **5**, as the liquid developer G is scraped off by the regulation blade **108** and lands on the liquid developer G at the landing position D, bubbles B and ripples W (waves) of the liquid surface are generated at the landing position D in the reservoir **102**.

Here, a developing device that does not include the blocking member **110** is examined as a comparative example. In this case, the liquid developer G is lifted as the supply roller **106** rotates, and thereby the liquid developer G is drawn toward the supply roller **106**. Accordingly, the liquid developer G flows from the landing position D toward the outer peripheral surface of the supply roller **106**. As a result, the bubbles B, which have been generated at the landing position D, are transported together with the liquid developer G on the outer peripheral surface of the supply roller **106**. Due to the presence of the ripples W of the liquid surface, which have been generated at the landing position D, the layer of the liquid developer G on the outer peripheral surface of the supply roller **106** may become nonuniform.

In contrast, with the developing device **100** according to the present exemplary embodiment, the blocking member **110** blocks the movement of the bubbles B and the ripples W of the liquid surface, which have been generated at the landing position D, before the bubbles B and the ripples W reach the supply roller **106**. Thus, the amount of bubbles B included in the developer G on the outer peripheral surface of the supply roller **106** is reduced and the ripples W of the liquid surface are suppressed. As a result, generation of nonuniformity in the layer of the liquid developer G on the outer peripheral surface of the supply roller **106** is suppressed, and therefore nonuniformity in a developer image formed on the outer peripheral surface of the photoconductor (see FIG. **1**) is reduced.

With the developing device **100**, the liquid surface of the liquid developer G rises when new liquid developer G is supplied by the developer supply portion **120** (see FIG. **2**). Then, a surface portion of the liquid developer G at the landing position D and in the vicinity of landing position D flows over the upper end of the second curved wall **102**B to the receiving portion **130**. Because the bubbles B generated at the landing position D are present in the surface portion, the bubbles B are removed together with the liquid developer G that overflows to the receiving portion **130**. Thus, the amount of bubbles in the surface portion of the liquid developer G adjacent to a side of the supply roller **106** at which the supply roller **106** moves from below to above the liquid surface is reduced.

With the developing device **100**, new liquid developer G is supplied from the deepest portion of the reservoir **102**, so that the new developer is not directly supplied to a position near the liquid surface of the liquid developer G. Thus, the amount of new liquid developer G (including only a small amount of bubbles, if any) that overflows to the receiving portion **130** before being supplied to the supply roller **106** is reduced.

Subsequently, as illustrated in FIG. **2**, the liquid developer G that has overflowed to the receiving portion **130** is recovered to the storage tank **122** as the pump **136** operates.

Second Exemplary Embodiment

Next, examples of a developing device, which is an example of an ink supply device, and an example of an image forming apparatus according to a second exemplary embodiment of the present invention will be described. Members and portions the same as those of the first exemplary embodiment will be denoted by the same numerals and description thereof will be omitted.

FIG. **6** illustrates a developing device **140**, which is an example of an ink supply device, according to the second the exemplary embodiment. The developing device **140** includes a reservoir **142** and an auxiliary roller **144** instead of the reservoir **102** of the developing device **100** (see FIG. **2**) according to the first exemplary embodiment. In other respects, the structure of the developing device **140** is the same as that of the developing device **100**. The developing device **140** includes the developer supply portion **120** (see FIG. **2**) and an overflow portion **150**. The overflow portion **150**, which is included in the reservoir **142**, includes a second curved wall **142**C (described below) that allows the liquid developer G to overflow. The overflow portion **150** further includes the receiving portion **130**, which receives the liquid developer G that has flowed over the second curved wall **142**C.

The reservoir **142** is, for example, a container extending in a longitudinal direction that is the same as the axial direction of the supply roller **106** and having a cross section taken along a plane intersecting the longitudinal direction that is open upward. To be specific, the reservoir **142** includes a lower wall **142**A, a first curved wall **142**B, and the second curved wall **142**C. When the reservoir **142** is seen in the longitudinal direction, the lower wall **142**A has a U-shaped cross section, the first curved wall **142**B extends from one of the upper ends (the right upper end in FIG. **6**) of the lower wall **142**A in a diagonally upward direction, and the second curved wall **142**C extends from the other upper end (the left upper end in FIG. **6**) of the lower wall **142**A in a diagonally upward direction.

The lower wall **142**A is disposed between the rotation center O of the supply roller **106** and has a shape that is open toward the outer peripheral surface of the supply roller **106**, and one end of the supply path **124** is connected to a bottom portion of the lower wall **142**A.

The first curved wall **142**B is a wall having an arc-shaped cross section extending diagonally rightward and upward in FIG. **6** from one of the upper ends of the lower wall **142**A. The first curved wall **142**B is disposed such that the distance between the first curved wall **142**B and the outer peripheral surface of the supply roller **106** is substantially uniform along the circumferential direction of the supply roller **106**.

The second curved wall **142**C is a wall having an arc-shaped cross section extending diagonally leftward and upward (toward the receiving portion **130**) in FIG. **6** from the other upper end of the lower wall **142**A. The second curved wall **142**C is disposed such that the distance between the second curved wall **142**C and the outer peripheral surface of the supply roller **106** is substantially uniform along the circumferential direction of the supply roller **106**. When the reservoir **142** is seen in the longitudinal direction, the upper end of the first curved wall **142**B is higher than that of the second curved wall **142**C. The liquid developer G is stored in the reservoir **142**.

Moreover, for example, the aforementioned liquid surface detection sensor (not shown), which measures the amount of the remaining liquid developer G, is disposed in the reservoir **142**. When the amount of the liquid developer G in the reservoir **142** decreases and become insufficient, the developer supply portion **120** (see FIG. **2**) supplies new liquid developer G to the reservoir **142**.

In addition, the receiving portion **130** is disposed outside of the second curved wall **142**C of the reservoir **142**. The upper end (the right upper end in FIG. **6**) of the receiving portion **130** is attached to the lower surface of the second curved wall **142**C. The blocking member **110** is disposed so as to extend from below to above the liquid surface of the liquid developer G at a position between the landing position D of the liquid developer G and the supply roller **106**. The blocking member **110** faces the outer peripheral surface of the supply roller **106**.

The leading end of the regulation blade **108** is in contact with the outer peripheral surface of the supply roller **106**.

The auxiliary roller **144** is a cylindrical member that is rotatable by a driving unit (not shown) about an axis extending in a direction the same as the axial direction of the supply roller **106**. The auxiliary roller **144** is disposed below the supply roller **106** so as to be surrounded by the lower wall **142**A. At a position at which the auxiliary roller **144** faces the outer peripheral surface of the supply roller **106**, the auxiliary roller **144** is separated from the outer peripheral surface of the supply roller **106** by a certain distance, and the auxiliary roller **144** moves (rotates) in the same direction as the supply roller **106** at the position. Moreover, there is a gap between the auxiliary roller **144** and the lower wall **142**A.

Operation

Next, the operation of the second the exemplary embodiment will be described.

As illustrated in FIG. **6**, a controller (not shown) of the developing device **140** activates the pump **126** (see FIG. **2**), and the liquid developer G is supplied from the storage tank **122** (see FIG. **2**) to the reservoir **142**. Thus, the height of the liquid surface of the liquid developer G in the reservoir **142** reaches the height of the upper end of the second curved wall **142**C.

Subsequently, as illustrated in FIG. **7**, the supply roller **106** and the auxiliary roller **144** start rotating when an image forming operation starts. At this time, the liquid developer G that has flowed into a narrow flow path between the supply roller **106** and the auxiliary roller **144** is pressed in the narrow flow path, and thereby bubbles B are removed. Thus, bubbles B in the liquid developer G that passes through the space between the supply roller **106** and the auxiliary roller **144** and that is carried on the outer peripheral surface of the supply roller **106** are reduced. A part of the liquid developer G carried on the outer peripheral surface of the supply roller **106** passes the regulation blade **108** and is supplied to the development roller **104** (see FIG. **2**), and the regulation blade **108** scrapes off the remaining part of the liquid developer G toward the reservoir **142**.

Subsequently, as the liquid developer G that has been scraped off by the regulation blade **108** lands onto the liquid developer G in the reservoir **142**, bubbles B and ripples (waves) of the liquid surface are generated at the landing position D. In FIG. **7**, the ripples on the liquid surface are not illustrated.

With the developing device **140**, the blocking member **110** blocks the movement of the bubbles B and the ripples on the liquid surface, which have been generated at the landing position D, before the bubbles B and the ripples reach the supply roller **106**. Thus, the amount of bubbles B included in the developer G on the outer peripheral surface of the supply roller **106** is reduced and the ripples on the liquid surface are suppressed. As a result, generation of nonuniformity in the layer of the liquid developer G on the outer peripheral surface of the supply roller **106** is suppressed, and thereby nonuniformity in a developer image formed on the outer peripheral surface of the photoconductor **12** (see FIG. **1**) is reduced.

With the developing device **140**, the liquid surface of the liquid developer G rises when new liquid developer G is supplied by the developer supply portion **120** (see FIG. **2**). Then, a surface portion of the liquid developer G at the landing position D and in the vicinity of landing position D flows over the upper end of the second curved wall **142**C to the receiving portion **130**. Because the bubbles B generated at the landing position D are present in the surface portion, the bubbles B are removed together with the liquid developer G that overflows to the receiving portion **130**. Thus, the amount of bubbles in the surface portion of the liquid developer G adjacent to a position at which the supply roller **106** emerges from the liquid surface is reduced.

With the developing device **140**, new liquid developer G is supplied from the deepest portion of the reservoir **142**, which is located at a lower position, the new developer is not supplied to a position near the liquid surface of the liquid developer G. Thus, the amount of new liquid developer G that overflows to the receiving portion **130** before being supplied to the supply roller **106** is reduced.

Moreover, with the developing device **140**, as the auxiliary roller **144** rotates, the liquid developer G that is located in a downstream part of the reservoir **142** in the rotation direction of the supply roller **106** is returned to an upstream part in the reservoir **142**. Thus, the difference between the heights of the liquid surface on the downstream side of the auxiliary roller **144** and on the upstream side of the auxiliary roller **144** in the reservoir **142** is reduced.

Subsequently, as the pump **136** (see FIG. **2**) is operated, the liquid developer G that has overflowed to the receiving portion **130** is recovered to the storage tank **122** (see FIG. **2**).

The present invention is not limited to the exemplary embodiments described above.

The shape of the blocking member **110** is not limited to a curved shape. Instead, the blocking member **110** may have a flat plate-like shape.

The charger **105** in the exemplary embodiments is a corotron charger. Alternatively, the charger **105** may be a scorotron charger. As a further alternative, other known chargers, such as a needle electrode or a pin-array charger (charging unit) may be used.

The image forming apparatus **10** is not limited to an apparatus that forms an image on a recording sheet P by using a monochrome liquid developer G. The image forming apparatus **10** may be an apparatus that forms an image on a recording sheet P by using a liquid developers G having different colors. For example, the image forming apparatus **10** may include plural developing devices **100** or plural developing devices **140** that are arranged therein.

Moreover, the toner concentration sensor **132** is not limited to an optical sensor. For example, the toner concentration sensor **132** may measure the toner concentration in the liquid developer G by using decaying of a supersonic wave.

The foregoing description of the exemplary embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, thereby enabling others skilled in the art to understand the invention for various embodiments and with the various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalents.

What is claimed is:

1. An ink supply device comprising:

a reservoir that stores ink;

an ink carrying rotary member that carries ink on an outer peripheral surface thereof;

a supply rotary member that is rotatable about a rotation axis that is parallel to a rotation axis of the ink carrying rotary member, the supply rotary member rotating and supplying the ink to the outer peripheral surface of the ink carrying rotary member while a part of the supply rotary member is immersed in the ink in the reservoir;

a regulation member that faces an outer peripheral surface of the supply rotary member, the regulation member regulating an amount of ink on the outer peripheral surface of the supply rotary member at a position outside of the reservoir; and

a blocking member that extends from below to above a liquid surface of the ink in the reservoir during an operating state where the ink carrying rotary member carries ink, the blocking member extending above the liquid surface at a position between a landing position and the supply rotary member, the landing position being a position at which ink that has been scraped off by the regulation member lands on the liquid surface, the blocking member blocking movement of the ink in the reservoir from the landing position to the supply rotary member,

wherein the blocking member extends along the rotation axis of the supply rotary member.

2. The ink supply device according to claim **1**, further comprising:

an ink supply unit that supplies ink into the reservoir, and

wherein the reservoir includes an overflow portion that allows ink to overflow from the ink reservoir outside of a wall of the reservoir, the wall being located opposite the supply rotary member with the landing position therebetween.

3. The ink supply device according to claim **2**,

wherein the overflow portion includes a receiving portion that receives the ink that has overflowed from the ink reservoir, the receiving portion being located outside of the wall.

4. An image forming apparatus comprising:

an image carrier that is rotatable, the image carrier carrying a latent image on an outer peripheral surface thereof;

the ink supply device according to claim **1**, the ink supply device supplying ink on the ink carrying rotary member to the latent image on the image carrier to form a toner image, the ink including a carrier liquid and a toner dispersed in the carrier liquid; and

a transfer unit that transfers the toner image on the image carrier to a recording medium.

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